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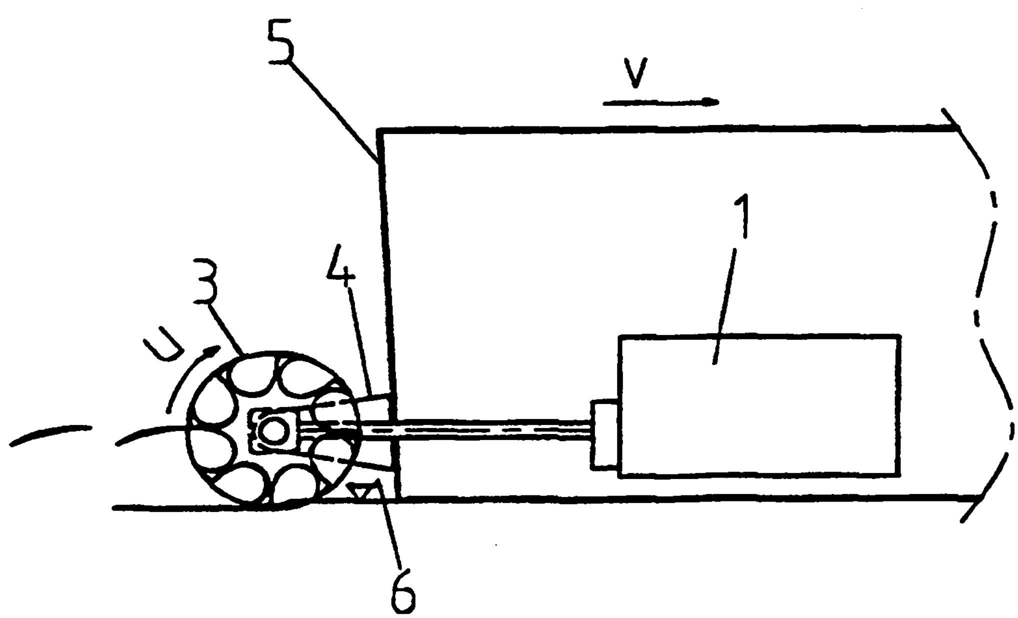

(57) Abstract

Machine-driven propulsion system for vessels where the propulsion force arises from a high-speed vane wheel having cup-shaped vanes open in the direction of rotation. The vane intake is provided with a cutting edge which penetrates down into a stable water surface beneath the vane wheel and brings up a defined amount of water which is strongly accelerated astern by the inside of the vane. The reactive force against the inside of the vane produces the propulsion force.

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Propulsion system.

The invention relates to a machine-driven propulsion system for ships/boats where the force of propulsion is obtained as reactive power in that a quantity of water (8) is accelerated astern by a rapidly rotating vane wheel with the axis transverse and with a direction of rotation so that the lower part of the wheel periphery goes astern relative to the ship, comprising a number of vanes positioned uniformly distributed along the circumference.

Dissimilar principles are known for the machine-driven propulsion of vessels. A conventional propeller, such as shown in Fig. 12, is almost supreme on conventional ships. It stands for well-tested technology, is simple, has easy axle guiding and exists with variable pitch for good control. At high speeds the conventional propeller has increased problems with cavitation, together with reduced efficiency.

The Voith Schneider propeller, as shown for instance in " Hydrodynamics of ships " by H. Valderhaug, Tapir publishing house 1972 page 201, is due to a highly expensive and complicated construction mainly used for vessels having extreme demands on manouevring ability.

Surface propellers as shown in Fig. 13 are exclusively used in high-speed vessels. It is a simple solution with easy axle control, and the cavitation problem at big speeds becomes largely eliminated. But the

efficiency is reduced based on intake loss/splash loss and oblique resultant thrust.

Water jets as shown in Figure 14 are mainly used in relatively high-speed vessels, but can and are made optimum for lower speeds. The advantage is a protected system, little draught, easy axle guiding and the utilisation of propulsion unity for powerful handling. Theoretical efficiency increases at higher speeds. The disadvantages in the system are intake cavitation, air suction, large internal wet surface, nozzle, guide vane and impeller loss, expensive system, the possibility of clogging of intake/impeller, demand for space and weight of amount of water in pipes.

Air propellers are used on high-speed light boats which can use water as propellant with difficulty. The efficiency is poor, particularly at low speeds.

Conventional vane wheels are little used in our day. A modified vane wheel solution according to the prior art is referred to in US Patent 3,251,334. The main principle according to this known solution is shown in Fig. 15. The vane wheel is equipped with a number of substantially radial vanes which during operation are pushed down in the underlying water surface to a depth which corresponds to the vane height. Blade intermediate spaces form pockets which are completely filled with water, and this becomes instantaneously accelerated up into the peripheral speed of the wheel. The centrifugal force and gravitational forces will then drain the wheel astern and obliquely upwards. An oblique plate placed behind the vane wheel utilises the vertical component of the discharge water. The system will produce large intake and splash losses, probably also intake cavitation and filling problems. Furthermore, large speed gradients in the water just beneath the wheel and in the vane intermediate spaces will produce friction losses and eddying losses. Draining of the vane intermediate spaces can also produce problems with suction owing to missing air for replenishing, which

will brake the accelerated water mass. Since the water in the blade intermediate spaces is not physically separated from the water beneath the vessel the instantaneous acceleration of the water will produce powerful pressure pulses which inter alia will create noise problems in the vessel.

The present invention has none of these disadvantages and a propeller system has been produced which achieves big advantages in respect of solutions within the state of the art.

The invention is characterised in that the vanes are cup-shaped with the opening in the direction of rotation, and comprises a cutting wedge-shaped front edge which with a small attack angle cuts down into the surface of the water to a certain depth, typically 5 - 30% of the vane height, and planes off a definite quantity of water which slides into the vane, and that the inside of the vanes are curved and specially designed so as to deflect the said quantity of water uniformly and accelerate it, the relative speed of the water against the vane inside being roughly unchanged, so that at the vane outlet it receives a direction approximately horizontally astern. Additional specific embodiments are defined in the dependent claims 2 - 11.

The reaction force are thus achieved in that by means of vanes designed for that purpose distributed along the circumference of a vane wheel with the axis transverse, having substantially larger peripheral speeds than the speed of the vessel, and having a rotational direction so that the lower part of the wheel periphery passes astern relative to the vessel, a quantity of water becomes physically separated from the main flow beneath the vane wheel and, since the relative speed against the inside of the vane typically does not alter especially, giving a uniform deflection approximately loss free astern of the curved inside (9) of the vane close to 180°. The absolute speed out of the vane becomes close to double the speed of

rotation of the vane referred to the middle of the vane with allowance for the speed of the vessel.

The invention will now be further explained with reference to the Figures, where:

Figure 1 shows a principally fore-and-aft section through the aft part of the vessel.

Figure 2 shows principally the aft part of the vessel seen from the upside.

Figure 3 shows an enlarged section through an embodiment of a typical vane.

Figure 4 shows detailed speed arrows and the hydrodynamic mode of operation for the free jet propeller, with the active vane in various positions.

Figure 5 shows a section through a construction of a vane wheel having arcuate cutting edges.

Figure 6 shows a construction of a vane wheel having oblique cutting edges in two directions.

Figure 7 shows a section through the drain-shaped discharge portion of a construction of a vane.

Figure 8 shows an embodiment of a reversing blade.

Figure 9 shows an embodiment of a free jet propeller equipped with a regulatable flap on the forward side.

Figure 10 shows a construction of a free jet propeller having a height adjustable blade wheel.

Figure 11 shows a construction of a free jet propeller having a blade wheel pivotable about a vertical axis.

Figure 12 shows a propulsion system having a conventional propeller according to the prior art.

Figure 13 shows a propulsion system having a surface propeller according to the prior art.

Figure 14 shows a propulsion system having a water jet according to the prior art.

Figure 15 shows a propulsion system having a modified blade wheel as is referred to in US Patent 3,251,334.

The basic principle for all machine-driven propulsion systems for ships is that an operating medium, such as

water, is accelerated astern relative to the ship by means of machine power. The reactive power from this acceleration produces propulsive power.

The invention comprises a propulsion system which uses two new principles, one for separating the active operating medium from the main current, and one for accelerating the active operating medium astern. This is the most important main distinction between the invention in accordance with the present application and the blade wheel which is referred to in US Patent 3,251,334. In addition to these new principles the invention as presented uses solutions which are known from conventional vane wheels, from surface propellers and from water jets.

As for surface propellers, vane wheels according to the state of the art and water jets, the free flow propeller according to the invention as presented uses the surface layer as operating medium. The free flow propeller comprises a vane wheel with a transverse axis which rotates so that the lower part of the vane wheel goes astern as in conventional vane wheels. As in water jets the free flow propeller separates a physically defined portion of the water, and uses this for operating medium. As in surface propellers it is only the pressure side of the vane/blade which accelerates the operating medium.

From Fig. 1 it is apparent that the main component of the system is the free flow propeller (3) as defined in claim 1. The free flow propeller is a relatively rapidly rotating vane wheel with the axis transverse at a suitable height above a water surface (6) which during operation is stable relative to the vessel, for instance the water surface just behind the stern on a planing vessel.

The effect from the engine (1) is transferred through the angle gear (2) to the free flow propeller (3) which is suspended in the bracket (4) on the square stern (5) of the vessel.

Along the circumference of the free flow propeller there are placed a number of cup-shaped vanes with

openings in the direction of rotation. Outer portions of these, typically 5 - 30% of the vane height are penetrating during operation down in the surface (6) of the water. The vanes have a special hydrodynamic design which enables them to isolate with minimal loss a certain amount (8) of water per vane, and this supplies astern great energy in the form of relatively uniform tangential acceleration. The vane wheel (3) resembles and works on a principle the opposite of a free flow turbine (Pelton-) wheel as shown for instance in " Water Power Machines" by A. Kjølle, University Publishing 1967, page 138. The peripheral speed (U) and the median peripheral speed (U_M) for the vane wheel are greater than the speed (V) of the vessel, typically (U) = 1.5 - 3,5 x (V). The cup-shaped tangential vanes have sharply cutting leading edges (7) planing off with a small attack angle a controlled amount of water (8) during passing through the water surface (6). The amount (8) of water has a relative speed (V_R) ≡ (U) - (V) relative to the tip of the vane, and this relative speed remains roughly unchanged through the vane. The uniformly curved inside (9) of the vane deflects the amount (8) of water gradually so that at the vane discharge it has a direction approximately straight astern. The deflection corresponds to an acceleration of the absolute speed for the amount (8) of water from about 0 to the flow speed (V_s), which typically is about the sum of the relative speed (V_R) and (U_M) - (V). The reactive force for this acceleration, with the resultant which acts forwards tangentially on the lower part of the vane wheel, produces the propulsive force.

A design of the inside (9) of the vane is formed as a drain towards the discharge, as is shown in Fig. 7, which collects the water for a relatively well-defined high-speed jet astern.

The advantages of the invention in respect of the known technology mentioned are <u>inter alia</u> :

1. The hydrodynamic effect transfer occurs very effectively in that the water is essentially only in contact with the well-defined inside (9) of the vane, which accelerates it uniformly to maximum speed. Particularly at higher speeds this will produce advantages of efficiency over conventional propellers, conventional vane wheels, vane wheels according to US Patent 3,251,334, surface propellers and water jets.

2. Rubbish in the sea will not be able to plug up the passage of fluid as in water jet systems, where the inlet strainer or impeller easily goes more or less clogged, something which reduces the efficiency drastically, and is besides a safety risk.

3. The risk of damage to the free flow propeller is small, both on collision with rubbish and on contact with the ground. Cordage will not have a tendency to wind itself on the vane wheel. Propeller damage is a significant expense, especially for speed boats in service in coastal waters.

4. Cavitation will hardly arise, since it is only the pressure side of the vane which accelerates the water. It is the cavitation problem <u>inter alia</u> which prevents the use of conventional propellers at higher speeds, and inlet and impeller/guide wheel cavitation limits the field of use for water jets.

5. The system will be able to be used effectively at the highest conceivable speeds.

6. The system utilises energy of the wake in the relatively thin boundary layer beneath the rapidly moving vessel in that the operating medium is fetched up from this. This energy goes lost when conventional propellers are used on high-speed planing ships.

7. The turbulence of the boundary layer beneath the ship will truly not affect the system especially. With conventional propellers this can produce noise, cavitation and loss of efficiency.

8. Possible power pulses which the system generates relative to the vessel have a resultant direction in the longitudinal direction of the vessel, and are led into the fore-and-aft solid main structure. On propeller operation the power pulses are fed to the aft part of the vessel in both vertical and transverse directions, this often producing a vibration problem in the hull.

9. The operating medium passes through the system without becoming supplied with rotational energy. In propeller and surface propeller systems the operating medium gets supplied with a considerable rotational energy, which largely goes to loss.

10. The active portion of the operating medium becomes according to the invention separated from the main current in that the wedge-shaped leading edge (7) of the vane with the small attack angle planes it out in a neat manner, so that the main current is disturbed to the minimum. With conventional propellers, surface propellers and vane wheels according to US Patent 3,251,334 the main current will on the other hand be characterised by large speed gradients and eddying, something which represents energy lost.

11. The invention as to arrangement is related to the propulsion system according to US Patent No. 3,251,334, but the mode of operation is essentially different, and the optimum propulsion system according to the invention will have a substantially higher efficiency for all speed zones of current interest.

An advantageous feature is that the vanes according to the invention only penetrates little, typically 5 - 30% of the vane height, down in the underlying surface (6) of the water. They have sharp, slim, wedge-shaped leading edges (7) which with small attack angles separates well-defined amounts (8) of water from the water surface (6), and accelerate these uniformly astern. While the discharge speed relative to the vessel for systems according to US Patent No. 3,251,334 is approximately equal to the median

peripheral speed of the vane wheel, for corresponding systems according to the invention it will be approximately equal to double the median peripheral speed of the vane wheel.

12. Effective reversing can take place by means of rear vanes as on water jets, as is shown in Fig. 8, and defined in claim 6, or in that the direction of rotation of the vane wheel is reversed.

13. Effective control can take place by control vanes as on water jets, according to claim 6, or by turning of the vane wheel relative to the longitudinal section of the boat, according to claims 9 and 10, see Fig. 11.

14. The adjustment of the effect supply to the system can take place by adjusting the number of rotations of the vane wheel, or in that the distance between the vane wheel axis and the water surface (6) below is adjusted. The adjustment of distance can occur in that the bracket (4) is displaceable in the height direction, according to claim 8, for instance as is apparent from Fig. 10, or in that the water surface level behind the boat is adjusted in the height direction by means of a adjustable flap (11), according to claim 7.

As is evident from the Figures the effect from the engine (1) is as mentioned transferred through the angle gear (2) to the free flow propeller (3). The peripheral speed (U) of the free flow propeller is substantially greater than the speed (V) of the vessel. The stable water surface (6) has a level relative to the free flow propeller (3) which enables the sharp vane leading edge (7) to penetrate down in the water and plane off a defined amount of water (8). This will deflect off by the inside (9) of the vane, and have a relative speed V_r in relation to this which is approximately equal to (U) - (V). The design of the inside (9) of the vane is adapted so that when the amount (8) of water reaches the vane outlet (10), the vane has rotated a certain angle, so that the amount (8) of water will have resulting speed V_s approximately

horizontally straight astern. During the passing of the vane inside (9) the absolute speed for the amount (8) of water is strongly accelerated astern.

Patent Claims

1. Machine-driven propulsion system for ships/boats where the propulsion force is obtained as a reactive force in that an amount (8) of water is accelerated astern by a rapidly rotating vane wheel with the axis transverse and with a direction of rotation so that the lower part of the wheel periphery goes astern relative to the ship, comprising a number of vanes placed uniformly distributed along the circumference, characterised in that the vanes are cup-shaped with the opening in the direction of rotation, and comprise a cutting wedge-shaped leading edge (7) which with a small attack angle cuts down into the surface (6) of the water to a certain depth, typically 5 - 30% of the height of the vane, and planes off a defined amount (8) of water which slides into the vane, and that the insides (9) of the vanes are curved and specially designed so as to deflect the said amount (8) of water uniformly and accelerate it, the relative speed of the water towards the vane inside being roughly unchanged, so that at the vane outlet it receives a direction approximately horizontally astern.

2. Machine-driven propulsion system according to claim 1, characterised in that the defined amount (8) of water slides into the vane with a relative speed ($V_R \equiv (U) - (V)$, and that the inside (9) of the vane deflects and accelerates the amount of water so that the speed astern is typically $(V_S) \cong (V_R) + ((U_M) - (V))$.

3. Machine-driven propulsion system according to claim 1 or 2, characterised in that the cutting edge (7) of the vane is arcuate so that water is also collected in from the sides of the vane wheel.

4. Machine-driven propulsion system according to claim 1 or 2, characterised in that the cutting edge (7) of the vane is oblique in one or two directions, so that a levelling/overlapping of the power impulses from the vanes is obtained.

5. Machine-driven propulsion system according to claim 1 or 2, characterised in that the inside (9) of the vane narrows towards the outlet and forms a drain, so that a relatively well-defined stream is formed when the water passes.

6. Machine-driven propulsion system according to claim 1 or 2, characterised in that reversing and turning of the vessel is carried out by means of deflecting vanes (12) as on a conventional water jet system.

7. Machine-driven propulsion system according to claim 1 or 2, characterised in that the level and direction of the stable water surface is adjusted by means of a regulatable flap (11) having a horizontal axis mounted so that the underside of the flap is level with the underside of the vessel.

8. Machine-driven propulsion system according to claim 1 or 2, characterised in that during operation it can be raised and lowered relative to the vessel so as to obtain adjustment thereby of the amount of water which the propeller brings up.

9. Machine-driven propeller system according to claim 1 or 2, characterised in that during operation it can be turned about a vertical axis so as to obtain thereby a control effect.

10. Machine-driven propeller system according to claim 1 or 2, characterised in that it is integrated as a propulsion element in an outboard motor, stern aggregate, z-drive or the like.

11. Machine-driven propulsion system according to claim 1 or 2, characterised in that it is constructed from a hub part having screwed on, easily replaceable vanes or vane parts.

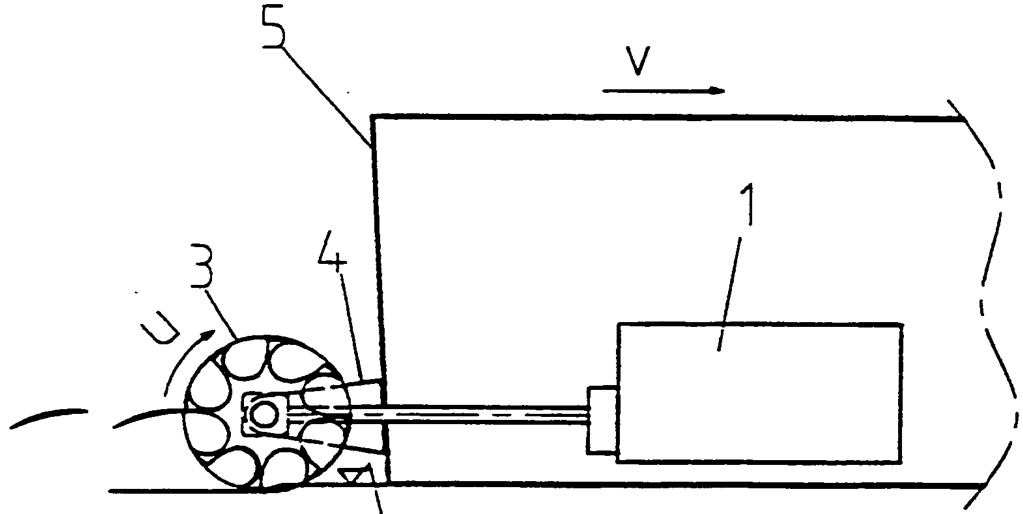

Fig.1

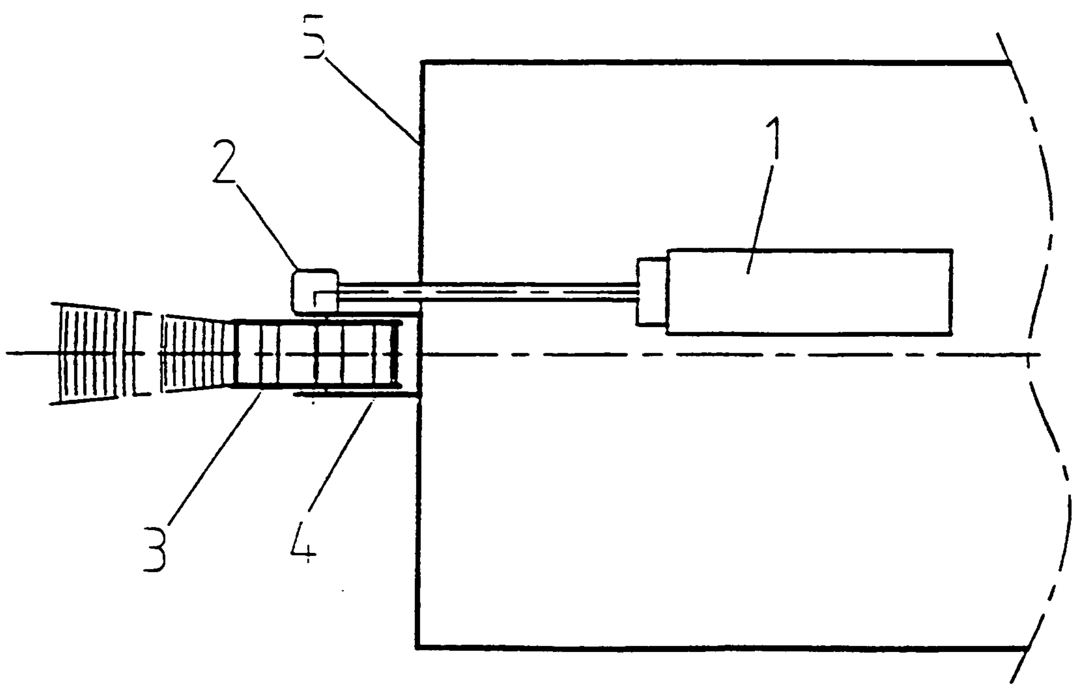

Fig.2

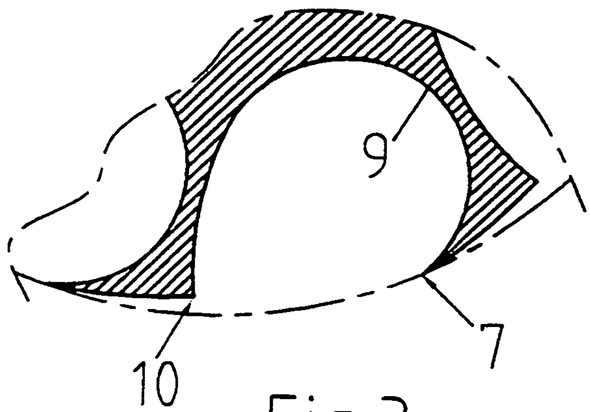

Fig.3

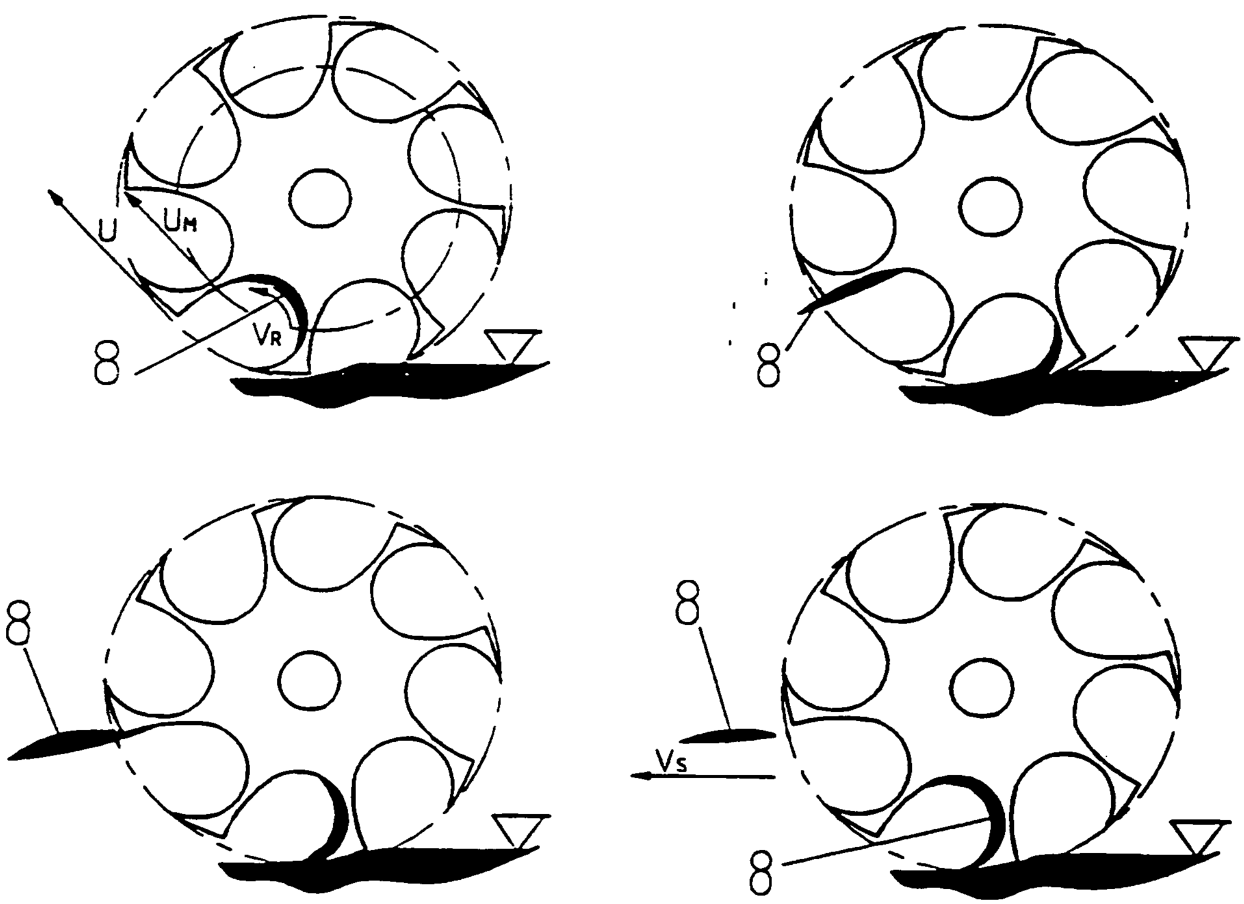

Fig.4

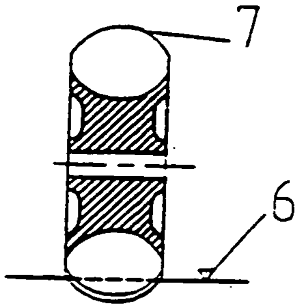

Fig.5

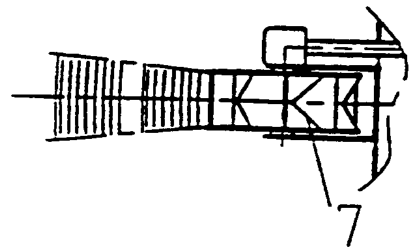

Fig.6

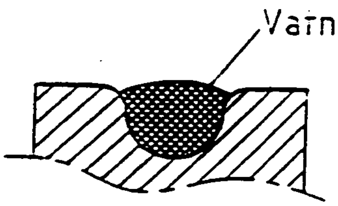

Fig.7

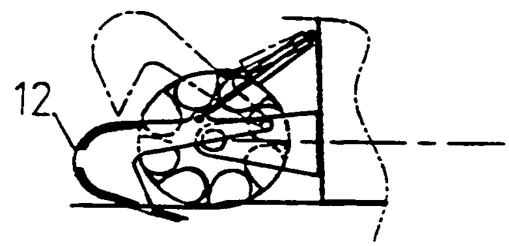

Fig.8

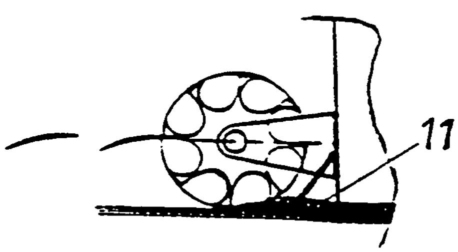

Fig.9

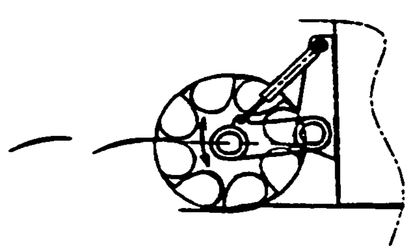

Fig.10

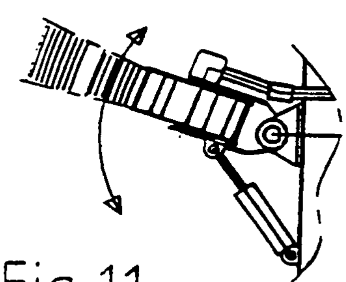

Fig.11

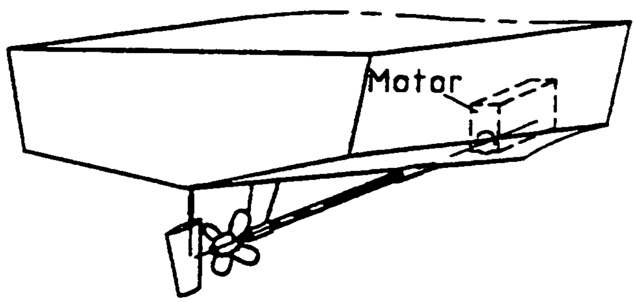

Fig.12

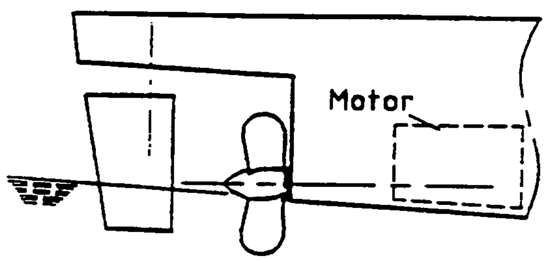

Fig.13

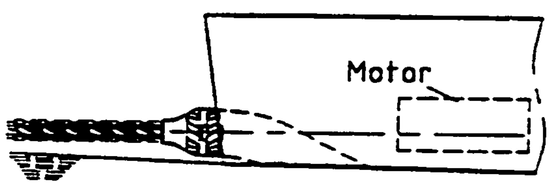

Fig.14

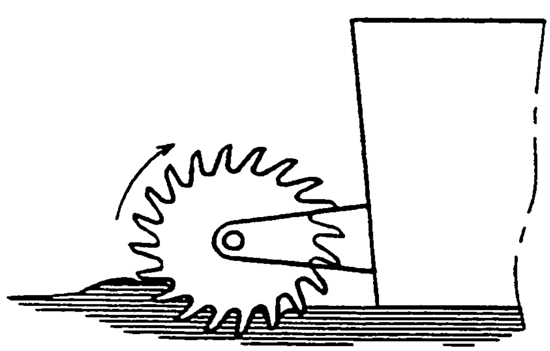

Fig.15

INTERNATIONAL SEARCH REPORT

International application No.
PCT/NO 98/00363

A. CLASSIFICATION OF SUBJECT MATTER

IPC6: B63H 11/02, B63H 1/04
According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC6: B63H

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

SE,DK,FI,NO classes as above

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

EPODOC

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 3759213 A (QUADY), 18 Sept 1973 (18.09.73), column 3, line 64 - column 4, line 38, figures 1-10, abstract --	1-11
A	US 3251334 A (M.W. BEARDSLEY), 17 May 1966 (17.05.66), figures 1-13 --	1-11
A	US 3076427 A (D.R. STAPLETON), 5 February 1963 (05.02.63), figures 1-9 -- --------	1-11

☐ Further documents are listed in the continuation of Box C.   ☒ See patent family annex.

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Date of the actual completion of the international search	Date of mailing of the international search report
24 February 1999	09-03-1999
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INTERNATIONAL SEARCH REPORT

Information on patent family members

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International application No.

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Patent document cited in search report	Publication date	Patent family member(s)	Publication date
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